712CD

75TH MORSS CD Cover Page

If you would like your presentation included in the 75th MORSS Final Report CD it must :

1. *Be unclassified, approved for public release, distribution unlimited, and is exempt from U.S. export licensing and other export approvals including the International Traffic in Arms Regulations (22CFR120 et seq.);*
2. Include MORS Form 712CD as the first page of the presentation;
3. Have an approved MORS form 712 A/B and
4. Be turned into the MORS office no later than: **DEADLINE: 14 June 2007 (Late submissions will not be included.)**

Author Request (To be completed by applicant) - The following author(s) request authority to disclose the following presentation in the MORSS Final Report, for inclusion on the MORSS CD and/or posting on the MORS web site.

Name of Principal Author and all other author(s): Aylward, Matthew M., Kathleen Boykins, Wayne Buck, Henry Washington

Principal Author's Organization and address:	Phone: 757-518-2216
MTS Technologies, Inc.	Fax: 757-518-2239
208 Golden Oak Court, Suite 100	Email: aylwardm@mtstech.com
Virginia Beach, VA 23452	

Please use the same title listed on the 75TH MORSS Disclosure Form 712 A/B. If the title of the presentation has changed please list both.)

Original title on 712 A/B: Simulation of OSCM Concepts for SAC-T

If the title was revised please list the original title above and the revised title here:

PRESENTED IN:

WORKING GROUP: 18	**DEMONSTRATION:**
COMPOSITE GROUP:	**POSTER:**
SPECIAL SESSION 1:	**TUTORIAL:**
SPECIAL SESSION 2:	**OTHER:**
SPECIAL SESSION 3:	

This presentation is believed to be: ***Unclassified, approved for public release, distribution unlimited, and is exempt from U.S. export licensing and other export approvals including the International Traffic in Arms Regulations (22CFR120 et seq.)***

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 JUN 2007	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Simulation of OSCM Concepts for HQ SACT	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **MTS Technologies, Inc. 208 Golden Oak Court, Suite 100 Virginia Beach, VA 23452**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM202526. Military Operations Research Society Symposium (75th) Held in Annapolis, Maryland on June 12-14, 2007, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**32**	

75th MORSS
Working Group 18

Simulation of OSCM Concepts for HQ SACT

Matt Aylward
Kathleen Boykins
Wayne Buck
Henry Washington

Agenda

- Background
- Thesis
- Toolbox
- Timeline
- Iteration One
  - Concept
  - Customer Expectations
  - Team
  - Information Collection
  - Approach
  - Build Cycle
  - Customer Feedback
- Iteration Two
  - Concept
  - Team
  - Approach
- Lessons Learned
- Results

Background

- During 4QFY06, Supreme Allied Command-Transformation (SAC-T) used modeling and simulation (M&S) to support Concept Development and Experimentation (CDE)

- Problem:
  - While the Nations' adeptly handle the inherent challenges of their own support chain, they are not as familiar with the complexities of the NATO Operations Support Chain
  - The current system presents the NATO commander with a special set of challenges, in terms of flexibility and responsiveness

- Operations Support Chain Management (OSCM) is a concept for organizing the support chain when the Nations operate under NATO command
  - Effect on the Nations, and response for the NATO Commander, not well known

Thesis

- Visualization of the complex interactions of equipment, supplies, transportation, personnel and command structures is an effective method for creating understanding, identifying problems and developing solutions.

- Simulation of a goal driven organization is a cost effective method to visualize some aspects of the problem space

Toolbox

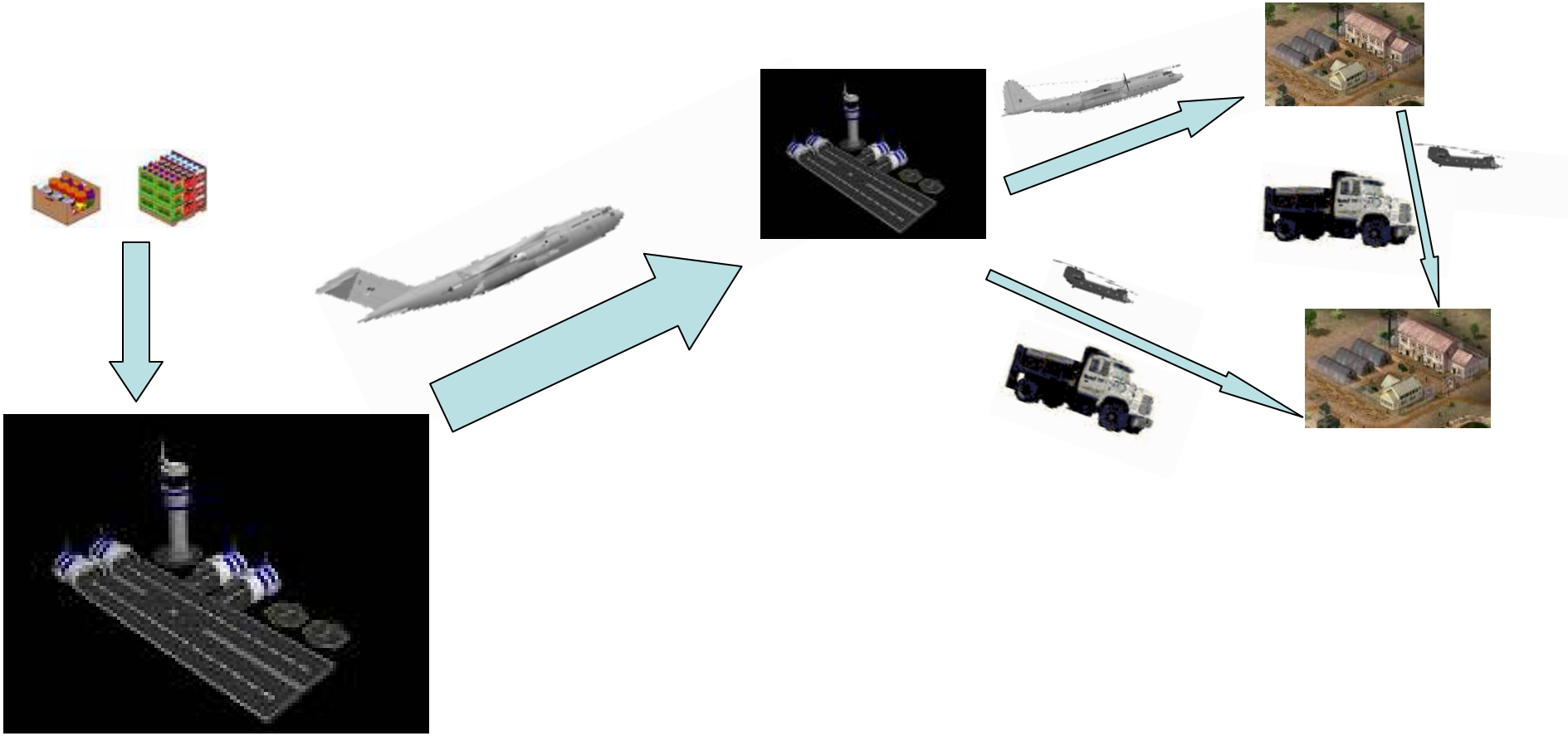
- The team used Extend™, a COTS product from Imagine That!® (http://www.imaginethatinc.com)
  - Graphic tool for building discrete event and continuous simulations
  - Animation capability built-in
- Visio™ used to develop process models
- Excel™ used to analyze historical data

Timeline

- Timeline was driven by the need to conduct demonstrations at high level events
- Early August – issue contract
- Mid-September - Demonstrate version 1 at NATO Industry Day
- November – discuss version 1 and 2 at Concept Development and Experimentation Conference
- December – Demonstrate version 2 at Riga Summit

Iteration One

- August to September 2006
  - ‘As-Is’ & ‘To-Be’ approach
  - Analytical flavor
  - Important lessons learned



Concept

- Concept for Operations Support Chain Management is immature (the reason why it needed visualization)
- Many stakeholders had differing views and perceptions of the same concept
- Two largest stakeholders are transportation and supply
- Used M&S to build a model which could be openly discussed

Customer Expectations

- The customer did not expect a decision support system (DSS). This is being built in parallel. The DSS can use some of the ideas from the visualization
- Customer needed to investigate both transportation and supply aspects
- Customer needed something to put in front of stakeholders

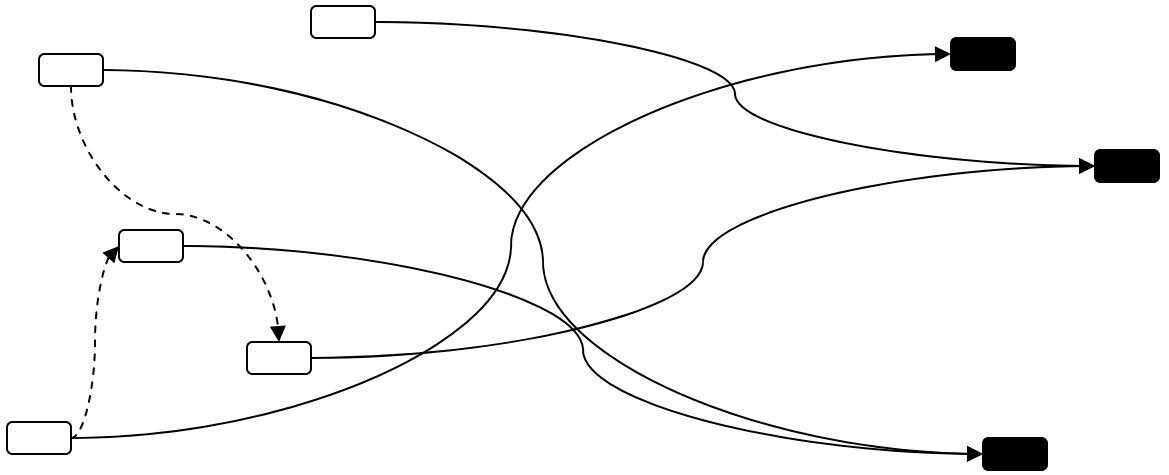
Team

- MTS Technologies contributed a senior analyst and two simulation developers
  - Simulation built in Virginia Beach, VA
- HQ SACT provided two personnel from the M&S Coordination Section and one SME from the Movement & Transportation Branch
  - Requirements development and information collection in at HQ SACT in Norfolk as well as various NATO activities in Europe

Information Collection

- HQ SACT provided process models for air and surface movement of supplies from TCN to ISAF theater
- HQ SACT personnel traveled to HQin Europe to collect data on procedures, frequency of flights, aircraft fleet, trends in material movement rates
- Some examples of the information developed follow

Information: Network Topology



- ‘As-Is’ ——→
- ‘To-Be’ - - - - - - - - - →
- T_{ij} Time to fly from the i^{th} APOE to the j^{th} APOD
- T_{ij} = f (distance, A/C speed)
- Cost to move cargo is in terms of C-130 Equivalent Flight Hours, where it costs €8K/hour to fly a C-130

Information: Aircraft Fleet

Nation	A/C Type	EFH	ECC	NNP	Capacity (KG)	Speed (KM/HR)	Unload Time (MIN)
All	C-130	1	1.0	5	22,800	546	90
Norway	Falcon 20	0.98	0.3	1	6,500	871	
UK	Bae-146	0.55	0.8	4	18,000	907	180
	C-17	7.1	3.4	17	76,650	796	135
Belgium	A-310	1.9	2.4	12	54,200	874	180
Germany	A-310	1.9	2.4	12	54,200	874	180
France	C-160	0.75	1.0	5.0	22,000	513	90
Denmark							
Switzerland							
Estonia							
Hungary							
Hungary							
Slovokia							
Romania							
Portugal							
Latvia							
Slovenia							
Sweden							

EFH: Equivalent Flight Hours-Cost Conversion

ECC: Equivalent Carrying Capacity-Lift Conversion

NNP: Number of Normalized Pallets-Study Specific

Information: Material Movement Rates

Nation	Ratio to UK	Apr	May	June	Jul	Aug	Total	Min	Avg	Max
UK	1.00	127,461	202,857	95,780	130,566	158,511	715,174	95,780	143,035	202,857
Belgium	0.12	15,295	24,343	11,494	15,668	19,021	85,821	11,494	17,164	24,343
Netherlands	0.25	31,865	50,714	23,945	32,642	39,628	178,794	23,945	35,759	50,714
Germany	0.40	50,984	81,143	38,312	52,226	63,404	286,070	38,312	57,214	81,143
Norway	0.30	38,238	60,857	28,734	39,170	47,553	214,552	28,734	42,910	60,857
Estonia	0.05	6,373	10,143	4,789	6,528	7,926	35,759	4,789	7,152	10,143
Hungary	0.30	38,238	60,857	28,734	39,170	47,553	214,552	28,734	42,910	60,857
Slovakia	0.09	11,471	18,257	8,620	11,751	14,266	64,366	8,620	12,873	18,257
Romania	0.40	50,984	81,143	38,312	52,226	63,404	286,070	38,312	57,214	81,143
Switzerland	0.20	25,492	40,571	19,156	26,113	31,702	143,035	19,156	28,607	40,571
Portugal	0.20	25,492	40,571	19,156	26,113	31,702	143,035	19,156	28,607	40,571
Latvia	0.09	11,471	18,257	8,620	11,751	14,266	64,366	8,620	12,873	18,257
Slovenia	0.09	11,471	18,257	8,620	11,751	14,266	64,366	8,620	12,873	18,257
Sweden	0.20	25,492	40,571	19,156	26,113	31,702	143,035	19,156	28,607	40,571
Denmark	0.15	19,119	30,429	14,367	19,585	23,777	107,276	14,367	21,455	30,429

Approach

- Planned approach:
  - Use support of the ISAF commander as a model for future operations
    - Develop a discrete event simulation to visualize choices made by the Troop Contributing Nations (TCN)
  - TCN behavior driven by the need to move a variable amount of material:
    - Satisfy the requirement (e.g., KG/month)
    - At the lowest cost
  - Explore effect of OSCM by presenting TCN with additional choice for moving material
    - Cost sharing added to the ‘To-Be’ system

Top-Level View

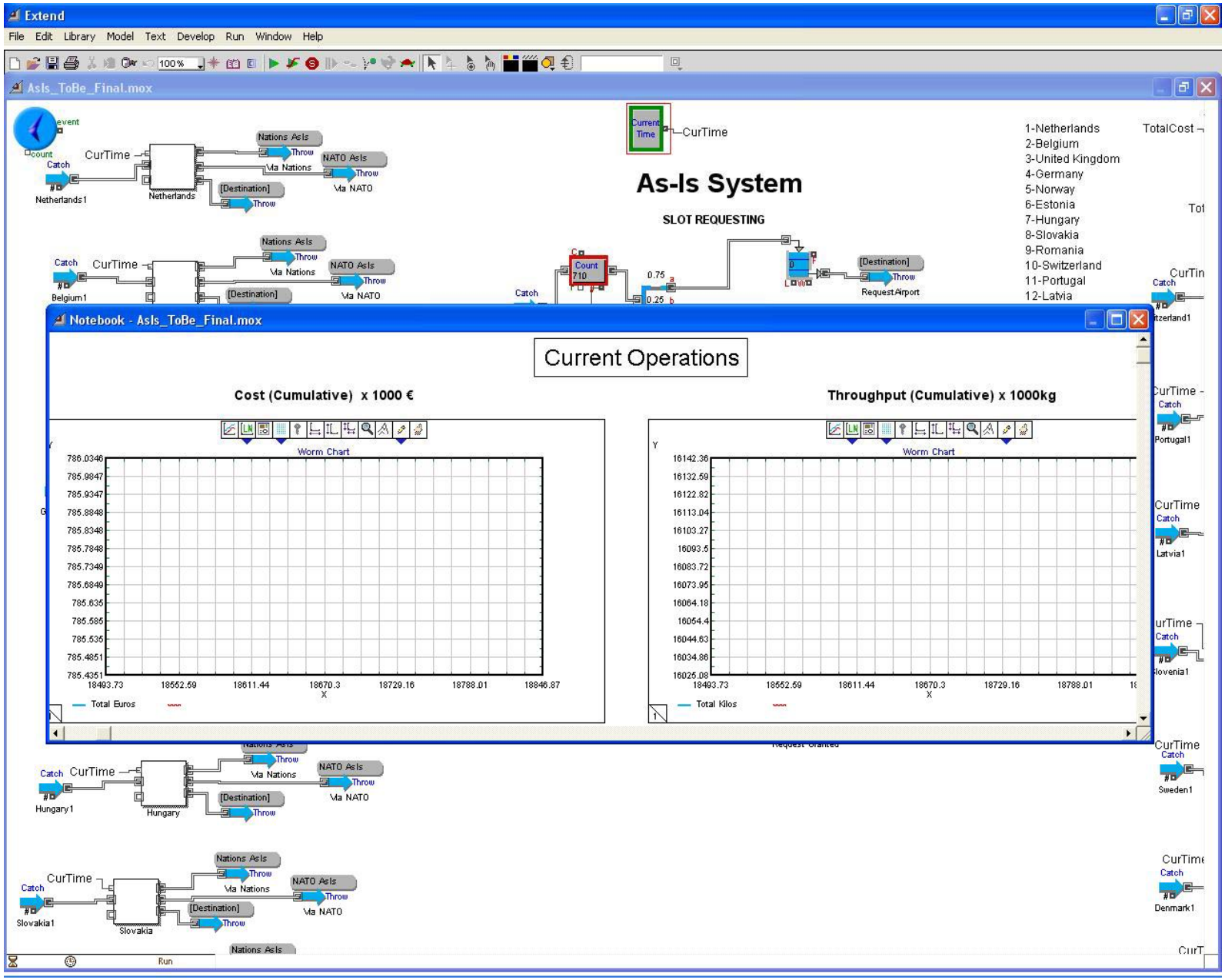
- **Step 1 ('As-Is' & 'To-Be'):** Each week, each TCN has to move a quantity of sustainment material from the Nation to Afghanistan
- **Step 2 ('As-Is' & 'To-Be'):** The number of pallets required to move the sustainment material is calculated
- **Step 3 ('As-Is'):** The TCN either uses its own A/C to move the sustainment material, or it uses the NATO ISAF Airbridge; ***with the choice depending on satisfying the delivery date at the lowest cost***
- **Step 3 ('To-Be'):** TCN choices are now: own A/C, NATO ISAF Airbridge, cost sharing program
- **Step 4 ('As-Is'):** Slot Request Form (SRF) submitted as needed, pallets batched with A/C, flight completed, A/C unloaded & serviced, A/C returns to Nation
- **Step 4 ('To-Be'):** SRF submitted as needed, *pallets moving via cost sharing program move to ConsolidationAPOD*, pallets batched with A/C, flight completed, A/C unloaded & serviced, A/C returns to Nation

Backup Slides

Build Cycle

Function Point	Build Cycle 1	Build Cycle 2	Build Cycle 3
Flights	Generate A/C & Pallets	Model Nations flow	Model OSCM ATARES flow
	Batching A/C & Pallets	Model ISAF Airbridge flow	
	Flying and unbatching		
A/C Fleet	Create resources	Calculate flight times	Calculate % capacity used
	Identify initial attributes		Calculate % capacity available
Network		ID Nodes	List APOE/APOD pairs
		ID Edges	Add ISAF Airbridge pairs
		Cost = f(length, A/C speed)	Intra-NATO pairs for OSCM ATARES
Metrics	Cost to carry: Euros & EFH	Design Visuals	Implement rough
	Delivery time	Choose graphs	Test for execution speed
	Throughput	Set variable windows	
	Capacity utilization		
TCN:SRF	Stub distributions:	Distribution for Yij	Global visibility for excess capacity on Yij
	# SRF/TCN/Unit time	Yij = #SRF from ith TCN to jth APOD	
	# SRF/TCN/Via AMCC/Unit time		
APOD	Reflect generic process	A/C queue on taxi-way	Holding tank releases A/C (FIFO queue) to APOD
		Unload time = f(#pallets/AC type)	Unload, service A/C, then release
		Scale unload process	
Pallet Demand	Characterize 'Pallet'	X~TRI (L, M, H)	X~Normal (mu, theta) (iff data analysis supports)
	Characterize typical load/AC	Where X is pallet demand	
	Characterize demand (#Pallets/Unit time)		
Business Rules	As-Is': TCN A/C -or- NATO ISAF	To-Be': TCN A/C, NATO ISAF or OSCM ATARES	Model behavior matches historical data
		Submit SRF via AMCC	Implementation speed
		Choose APOD	

Results

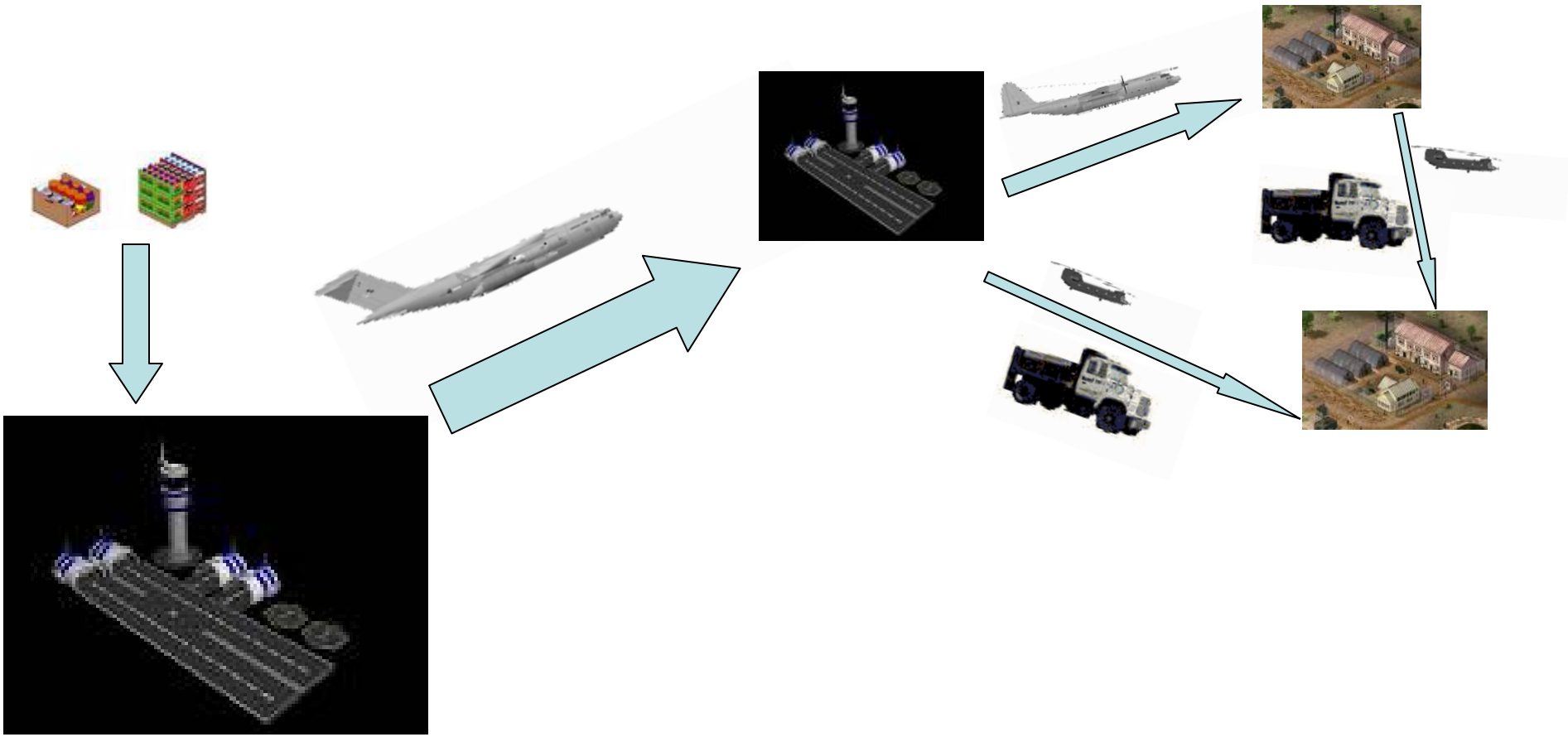

Extend
File Edit Library Model Text Develop Run Window Help
AsIs_ToBe_Final.mox
As-Is System
SLOT REQUESTING
1-Netherlands
2-Belgium
3-United Kingdom
4-Germany
5-Norway
6-Estonia
7-Hungary
8-Slovakia
9-Romania
10-Switzerland
11-Portugal
12-Latvia
TotalCost
Notebook - AsIs_ToBe_Final.mox
Current Operations
Cost (Cumulative) x 1000 €
Throughput (Cumulative) x 1000kg
Worm Chart
Total Euros
Total Kilos
Nations AsIs
NATO AsIs
Via Nations
Via NATO
[Destination]
Request Airport
Netherlands1
Belgium1
Hungary1
Slovakia1
Portugal1
Latvia1
Slovenia1
Sweden1
Denmark1
Run

Customer Feedback

- Underlying analysis is good
- Dashboard has limited utility
- Doesn’t help us ‘see’ the problem space
- Customer relied on only one transportation SME to instruct simulationists and was surprised that supply aspects were not present in the simulation.
- What about:
  - Deploy/sustain/re-deploy sequence?
  - Intra-theater movement
  - Sustainment is good, but what about an operational plan?

Iteration Two

- September-October 2006
  - Focus on Riga Summit
  - Operational scenario
  - Animate System Behavior



Concept

- Although the concept had not matured the manner in which the concept developers looked at the problem had changed.
- The first iteration forced the concept developers to be much more inclusive in their thinking

Team

- Same group as in iteration one
- Addition of supply SME from the Integrated Logistics Branch; slated to present the model at Riga

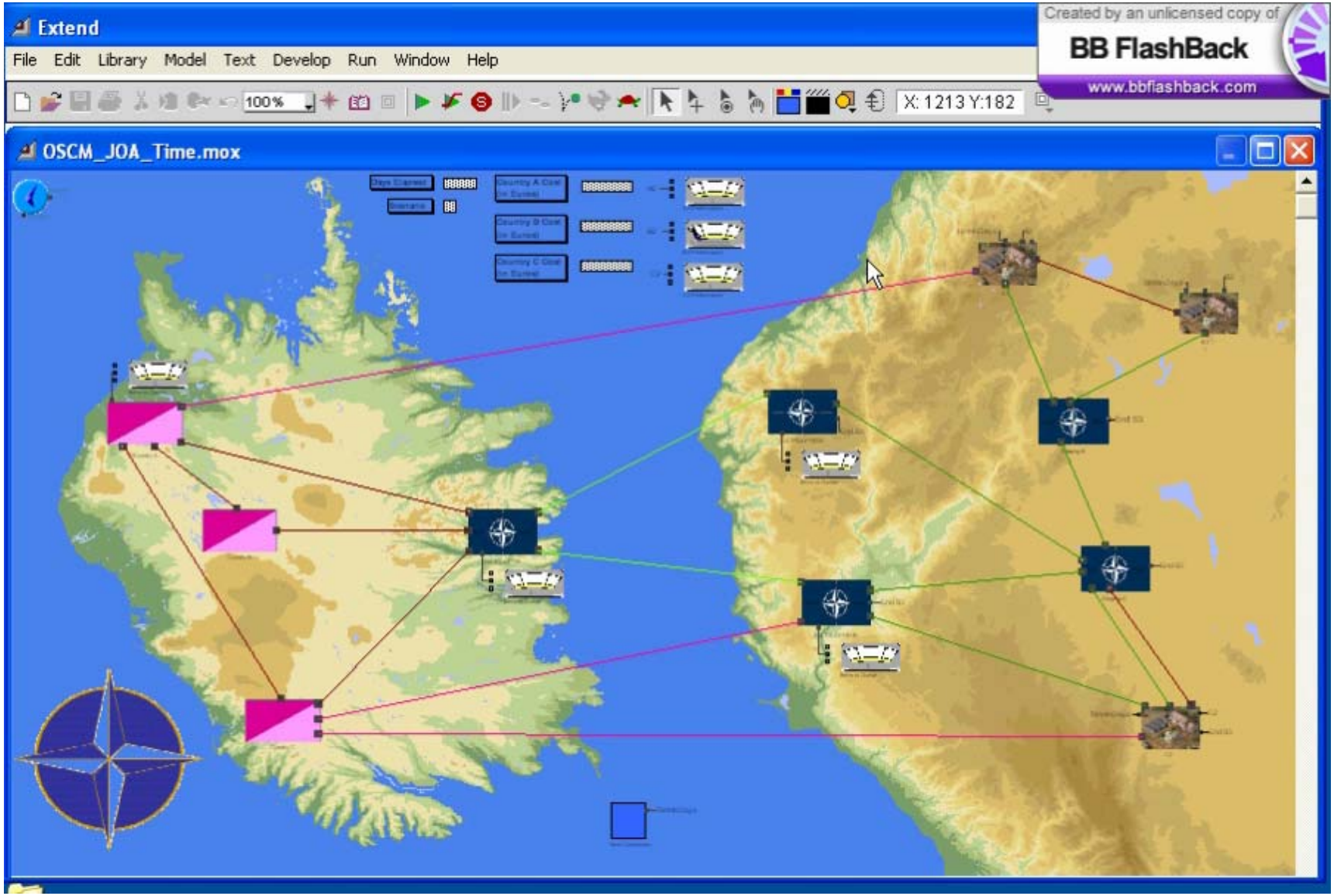
Approach

- SAC-T provides an operational scenario with multiple phases:
  - Deploy from TCN to theater
  - Sustain for multi-day period
  - Shift mechanized force from south to north of operating area
- Leverage experience from iteration one to create goal driven entities
- Focus of movement path shifts from inter-theater air to intra-theater ground as the scenario progresses
- Metrics emphasize utility of OSCM in meeting NATO commander's goals for re-deployment of forces
  - Difference between relying on TCN logistic capability and having the means to directly influence the movement
  - Trading readiness (i.e., DOS on-hand) for reduced re-deployment time
- Animation of system behavior critical for starting dialogs at Riga summit

Lessons Learned

- Compressed schedule forced team to concentrate on key elements of the problem space; proved to be beneficial in development cycle
- Stochastic approach driven by obstacles to gathering data; allowed for UNCLASS approach, customer able to easily adjust parameters to match actual data
- Visualization critical for conveying complex ideas across a multi-nation coalition

Results


Extend
File Edit Library Model Text Develop Run Window Help
100%
X: 1213 Y:182
Created by an unlicensed copy of
BB FlashBack
www.bbflashback.com
OSCM_JOA_Time.mox

Results

- Customer is pleased with results and expects to do more iterations
- Customer now wants to use the simulation as a DSS. It was explained to the customer early on that this would not be a good idea, especially as the customer is having a DSS built in parallel.
- Expectation management is a key aspect of this work.

Backup Slides

Random Variables and Conversion Factors

- Pallet Weight (PW) ~ TRI (2955, 3636, 4545) (KG)
  - For this study, a C-130 carries a maximum of five (5) of our normalized pallets
- During the m^{th} week, the i^{th} TCN must move an amount of sustainment cargo.
  - $BPOS_{im}$ ~ TRI (Low, Avg., High) (KG)
- Pallets to Move (PTM) = $BPOS_{im}$ /PW
- EFH = (# TCN_i Pallets/AC_k Capacity)*(Flight Time)*(Conversion Factor)
  - Capacity, Flight Time, Conversion Factor are specific to AC_k
  - Operating cost of a C-130 is £8,000/hour, or €11,886, at the current exchange rate
- TCN aircraft fleet is not constrained, but some Nations may have to lease AC
  - TCN_Owns is the probability that the Nation doesn't have to lease an aircraft: TCN_Owns ~ Binomial (p=*x*), where *x* varies by Nation
  - Each time a TCN elects to fly its own cargo, TCN_Owns is checked
  - If the Nation has to lease, then its cost is incremented by €35K (i.e., the cost to lease an IL-76), plus the operating cost for that particular flight

Return to Brief

Behavior Sequence: 'As-Is'

- Poisson fires, initiating action by TCN
  - λ = 1/week
- Calculate PTM
- PTM (DIV) Capacity AC_k = # SRF (i.e., Nation will fly the cargo)
  - AC_k is the largest plane in the TCN's fleet
  - Check TCN_Owns
- PTM (MOD) Capacity AC_k = # Pallets to move on:
  - Nations' AC (Additional SRF)
  - NATO ISAF Airbridge (at €3/KG)

} -Respect TOD
-Minimize Cost

Return to Brief

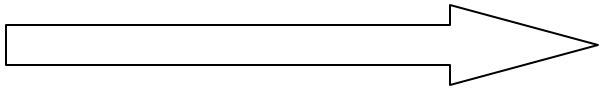
Behavior Sequence: 'To-Be'

- Poisson fires, initiating action by TCN
  - λ = 1/week
- Calculate PTM
- PTM (DIV) Capacity AC_k = # SRF (i.e., Nation will fly the cargo)
  - AC_k is the largest plane in the TCN's fleet
  - Check TCN_Owns
- PTM (MOD) Capacity AC_k = # Pallets to move on:
  - Nations' AC (Additional SRF)
  - NATO ISAF Airbridge (at €3/KG)
  - Cost sharing program

-Respect TOD
-Minimize Cost

Return to Brief

More on the Cost Sharing Decision



‘To-Be’: Cost Sharing Decision

- First decide to fly (gain EFH Credits) or ride (accumulate EFH Debits)
- ToFly
  - Let Y=Capacity AC_k
  - Let X=PTM (MOD) Capacity AC_k
  - IF .5Y < X <Y THEN ToFly ~ Bernoulli (p=0.5) *Where success means Nation will fly*
- To Ride
  - Is there an ISAF member with sufficient excess capacity, going to the same APOD?
  - Will my TOD be respected?
- Fallback: if ToRide and ISAF Airbridge are infeasible, then Nations’ default is ToFly

Return to Brief